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Research on the cleaning efficacy of micro-bubbles on dental plaque

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Abstract

Long-term bed-ridden patients do not usually have the same opportunity for proper dental hygiene as normal individuals, as they often have difficulty using toothbrushes to clean their teeth. Patients with periodontal disease are also at risk of increased bacterial infection due to the propensity for teeth brushing causing bleeding of the gums. Therefore, an alternative method of dental hygiene maintenance is required for these individuals. Our study proposed a method to clean dental plaque through a tooth tray with micro-bubbles and verified its cleaning efficacy through experiment. A cleaning device that produces micro bubbles (Braun MD20) was used in the study with five separately modified nozzle diameters as the independent variable: 0.16mm, 0.30mm, 0.63mm, 0.8mmand 1.2mm. The five different rotation speed settings of the device act as the other independent variable, with the resulting flow volume, velocity and the diameter of the micro-bubbles as the intermediate variables. The effects of these variables on cleaning dental plaque were investigated. Our results showed that an average of 45%~75% cleaning rate of dental plaque was achieved under all combinations of the variables. The best dental plaque removal variable combination was nozzle diameter 0.8mm with speed of 3527 rpm, in which 98% dental plaque removal was achieved. The dimension of the nozzle exerted greater influence on flow volume, flow velocity and bubble diameter than rotation speed. The effect of the control variables on plaque removal was also more significant than intermediate variables, with the nozzle dimension influencing plaque removal at 0.05 significance level.

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Keywords: Micro-bubble; Dental plaque; Tooth tray; Periodontal disease

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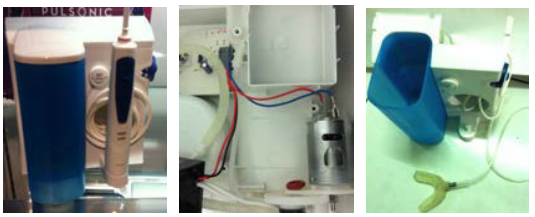

Fig. 1. Braun MD20 (left), internal structure (center) and modified device (right).

1. Introduction

For this study, we questioned many care centers and learned that many long-term bed-ridden chronic or hand paralysis patients have more difficulty in dental hygiene than normal individuals. Some patients require assistance from nursing staff; others rely on external help to clean their oral cavities. However, due to individual differences in dimensions of oral cavities, teeth size, shapes and arrangements, the brushing assistant may not always have a good grasp of the brushing feeling as experienced by the patient. This often resulted in increased difficulty of maintaining dental hygiene. Differences in personal hygiene and dietary habits also contributed to the many different bacteria strains in the oral cavity. Current information on dental plaque has listed more than 25,000 bacteria strains in the oral cavity; up to 10,000 different bacteria may exist in the mouth of just one individual [9]. As stated in the《Fundamentals of Oral Histology and Physiology》by Hand and Frank (2014), teeth is the part of the mouth where most bacteria are found, as they easily form biomembranes over the surface of the teeth. When acidic materials began to erode the enamel, the teeth loses the ability of self-protection. The bacteria on the surface of the teeth and mucosa grow on the nutrients from the saliva; sufficient nutrients will result in elevated bacteria on the dental surface, forming dental plaques and hampers dental and gingival hygiene. Therefore, maintaining oral hygiene is essential, and the most common method to do so is through teeth brushing with toothbrush and toothpaste. However, brushing teeth with gingivitis may cause bleeding of the gum, which may lead to development of periodontal disease in diabetic patients whose wound healing ability is impaired, causing bacteria to growth on the gum. Studies have also shown that diabetic patients with periodontal diseases are more likely to develop destructive periodontitis [8,10] . Onaga et al (2006) have studied the use of ultrasound-induced micro-bubbles to clean dental plaque, and their results show that effective dental plaque removal can be achieved. However, this study has not yet been performed in human oral cavities. Various methods produce micro-bubbles. Onaga et al used ultrasound, and our study proposed a simpler method that produces micro-bubbles through mixing of water and air via a motor, and employed through a specially designed tooth tray to clean the dental plaques. Our study not only verifies that micro-bubbles produced from different devices have the same dental plaque removal capability, but also hopes to further investigate the relationship between plaque removal efficacy and different variables. There are currently many different types of air and water combination apparatus on the markets that produce micro-bubbles. For our study, we will be using the currently available Braun MD20 micro-bubble dental irrigator. The path of the micro-bubble will be modified to control the variables of bubble formation to suit the needs of our study (as shown in Fig. 1)

2. Literary reviews

2.1. Principles of micro-bubble formation and application in cleaning

Bubbles are formed in many of the natural processes. When gases and liquids are combined under pressure, bubbles of various sizes and shapes are formed. Bubbles can also be formed by emitting electricity, depressurization, increase temperature, ultrasound and electrolysis of various liquids. The bubble formation process, after multiple splitting, will result in very small dimensions, forming the so-called micro-bubbles. Based on the disintegration of air in the water, Fujikawa (2003) developed a device that produces micro-bubbles by channeling air through a compressor into a flat plate drilled with many pores, and controlled the rotation speed of the plate with a motor. This device uses shear force to slice through the bubbles, which decreases the bubble diameter with increasing rotation speed. Common applications of micro-bubbles are 1) cleaning action: detergent solution is